UDC 666.1.022:666.123.22:666.1.031

SPECIFICS OF BATCH PREPARATION AND GLASS MELTING USING DIFFERENT TYPES OF SODA FOR PRODUCTION OF SHEET GLASS

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Translated from Steklo i Keramika, No. 5, pp. 14 – 16, May, 2003.

The experience of using lightweight and heavy soda produced by Soda JSC (Sterlitamak) and technical soda ash of grade 2 based on nepheline material produced by the Achinskii Alumina Works in a continuous process of producing light-heat-shielding bulk-tinted float sheet glass is considered. The advantages and disadvantages of alkali materials are analyzed. The specifics of preparing batch and glass melting using various types of soda are investigated.

Use of each new kind of material in production should be preceded by detailed investigation of its granulometric, mineralogical, and chemical composition and its effect on melting and working properties of glass, since even slight modifications in the chemical composition, granulometry, and moisture have an effect on the melting rate, batch quality, and glass properties.

The present study describes the experience of using "lightweight" and "heavy" (granulated) soda produced by Soda JSC (Sterlitamak) and technical soda ash of grade 2 based on nepheline material produced by the Achinskii Alumina Works (GOST 10689–75, GOST 5100–85) [1 – 3] in a continuous process of making light-and-heat-shielding bulk-tinted sheet glass. The chemical compositions and relative properties of alkali materials are listed in Tables 1 and 2.

The technological suitability of materials depends primarily on its behavior in storage. All kinds of alkali-bearing materials cake, consolidate, or clot, and in moist conditions transform into crystal hydrates [2, 4].

Observation revealed that after seven days of storage in natural conditions lightweight soda could be poured out only after intense shaking. Clots ranging from 0.2 to 1.0 mm in diameter comprise 14% of the total weight of the sample. However, after light mechanical action (rubbing between fingers) the clots disintegrate. Heavy soda does not cake or clot. In grade-2 soda based on nepheline material clots 0.2 – 3.0 mm in diameter comprise 25% of the total weight and can be removed by a rougher physical impact. Moisture accumulation is equal to about 2% in lightweight soda, 1.5% in granulated soda, and 3% in Achinskaya grade-2 soda from nepheline material. Batches in storing behave similarly to the respective soda varieties. Since Achinskaya soda is 1.5 times more hygroscopic than light soda, its batch gets more caked and clotted.

The advantages of lightweight soda include a high content of its main material (Na_2CO_3), a low content of impurities and, consequently, low waste of the batch. The disadvantages include poor miscibility with other components, stratification of batch in storage, and substantial volatilization in charging. A low bulk density raises the storage and transportation cost for this soda variety [4, 5].

Granulated soda is less prone to caking and dusting, can be easily stored in a hopper, and has high friability. All this improves the conditions of batch mixing and glass melting. However, stratification of batch is observed in storage [4].

The advantage of soda based on nepheline material is its high bulk density, consistency with other raw materials in its granulometric composition, and presence of potassium compounds that have a positive effect in the production of tinted glass. Its main disadvantage is its high hygroscopy which im-

TABLE 1

Soda	Mass content, %			
	Na_2CO_3	NaCl	Na_2SO_4	Fe_2O_3
"Lightweight":				
Sterlitamakskaya	99.22	0.49	0.05	0.003
Krymskaya	98.95	0.60	0.05	0.003
Bereznikovskaya	99.00	0.54	0.05	0.003
"Heavy" granulated Sterlitamakskaya	99.31	0.52	0.02	–
Achinskaya,* grade 2, based on nepheline material	93.00 – 87.00	–	0.002	0.010 – 0.020

* In addition Achinskaya soda contained 4.20 – 6.50 K_2CO_3 and 2.50 – 6.48 K_2SO_4.

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pairs the quality and grade of soda in storage and leads to poor miscibility with other components, disturbance of homogeneity during batch preparation, and reduced quality of the finished batch [6]. Thus, in using the lightweight Sterlitamakskaya soda, the yield of batch of categories 1 and 2 is 80 – 85% and in using Achinskaya soda it decreases to 55 – 60%.

In continuous production of light-heat-shielding bulk-tinted glass no significant modification of batch preparation was needed when changing from lightweight to heavy soda. The quality of the batch produced met the requirement of technological regulations [5].

Application of grade-2 soda from nepheline material made it necessary to develop a special cyclogram of batch preparation, which brought the yield of high-quality batch (categories I + II) to 87 – 89% [5].

The effect of replacement of alkali-bearing material by another on the melting properties of glass was studied using a set of independent and mutually complementing methods, including polythermy of batches, thermoanalytical analysis (DTA) of batches and alkali materials, the Zak – Ponomarev method for determining the melting rate [7], experimental melting in electric laboratory furnaces, in experimental-industrial conditions in a batch gas-flame furnace of capacity 600 kg, and on a float glass line with an output of 100 tons/day.

Thermoanalytical analysis was carried out using an OD-103 derivatograph in a polythermic regime within a temperature interval if 20 – 1000°C with a heating rate of 10 K/min. The shape of DTA and TG curves (Fig. 1) points to the similarity of the main processes in the experimental batches under thermal treatment.

However, it should be noted that the decomposition processes in batch 2 are quite intense at lower temperatures, which is indicated by additional endothermic effects and a modification of the TG curve angle. The maximum decomposition effect correlates with a temperature of 810°C, and silicate formation in batch 2 ends at a temperature of 950°C, whereas in batches 3 and 4 it ends at 970°C.

The polythermic method gives qualitative characteristics of processes occurring in batches under heating and specifies the temperature boundaries of transformation of the batch

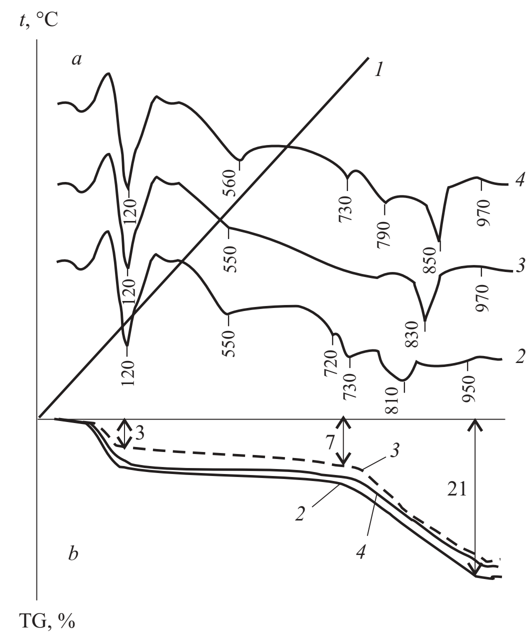

Fig. 1. Thermograms of experimental batches (curve numbers *2 – 4* correspond to batch numbers): *a*) thermal effects (DTA) curves of batches; *b*) weight losses in batches; *1*) heating curve; *2*, *3*, and *4*) batches containing technical soda ash of grade 2 soda from nepheline material, heavy soda, and lightweight soda, respectively.

into melted glass. A comparative analysis of melting processes in experimental batches within a temperature interval of 600 – 1400°C indicated that the sintering and glass formation boundaries in batch 2 are shifted by 20 – 23°C to a lower temperature range.

The results obtained in estimating the glass-formation rate using the Zak – Ponomarev method corroborated the good melting properties of the batch containing soda based on nepheline material. Glass melt samples of batch 2 became clear in 72 min, whereas batch 4 sample clarified in 80 min.

To evaluate clarification, melted glass was exposed in an electric furnace at a maximum temperature of 1450°C for 0.5 – 2 h. The degree of clarification was estimated based on the number of bubbles per volume unit (1 cm^3) of sample. It was found that glass melt based on Achinskaya soda is more gas-saturated. Consequently, in using soda of grade 2 based

TABLE 2

Parameter	Lightweight soda*			Heavy granulated Sterlitamakskaya soda**	Achinskaya soda,*** grade 2, based on nepheline material
	Sterlitamakskaya	Krymskaya	Bereznikovskaya		
Bulk density, g/cm^3	0.63	0.65	0.65	0.90 – 1.00	1.23
Melting temperature, °C	852	852	852	830	810
Particle size, mm	0.06 – 0.20	0.06 – 0.20	0.06 – 0.20	0.20 – 1.20	0.20 – 0.60

* White powder.

** White or grayish granules.

*** Grayish-white powder.

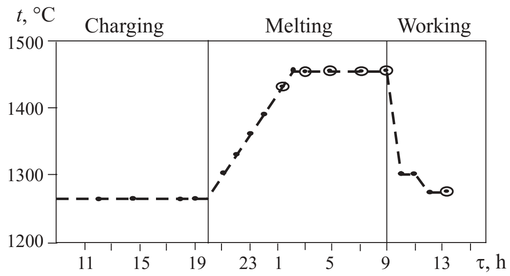

Fig. 2. Temperature-time conditions of experimental glass melting in experimental-industrial conditions: •) sampling.

on nepheline material one can expect acceleration of the melting process at the stage of silicate and glass formation, but a longer exposure in the range of high temperatures is needed to produce high-quality clarified glass melt.

However, a series of experimental melting in a gas-flame batch furnace of 600-kg capacity in experimental-industrial conditions proved that glass synthesis involving large batch volumes using different types of soda proceeds in similar temperature-time conditions (Fig. 2).

The working properties of the experimental glasses were estimated by mass crystallization and polythermy [7]. It was found that all the synthesized glasses have a low propensity for crystallization. The liquidus temperature is within the limits of 1015 – 1020°C, and the emerging crystalline phase is β-wollastonite.

The optical characteristics of the experimental glasses were studied on a Specord M40 spectrophotometer. It was observed that replacement of alkali-bearing material does not affect the shape of the spectral curves. However, glasses synthesized with Achinskaya soda have a saturated color tone. The results of the studies show the advisability of using grade-2 soda based on nepheline material in production of sheet glass.

Between 1998 and 2001 soda produced at the Achinskii Alumina Works was used as the main alkali-bearing component in the continuous production of light-and-heat-shielding bulk-tinted float glass. The temperature-gas regimes of the glass-melting furnace and the melting tank did not require significant changes. This float-glass line produced high-quality glass that was used in construction, car windows, and three-ply and multi-ply window panes. Moreover, soda based on nepheline materials was successfully used in experimental research and development of compositions and technologies for decorative glass varieties, including opacified glass [8, 9].

Long-term experience indicated that the main technological problem in using grade-2 soda from the Achinskii Works was due to frequent fluctuations in the content of the main material in the chemical composition, which complicated the process, since the batch formula needed to be constantly corrected. The instability of the potassium component (K_2CO_3, K_2SO_4) affects the reproducibility and color tone constancy of glass produced, which leads to changes in the concentration interval of the colorant additives, oxidizers, and reducing agents. Accordingly, starting with 2001, lightweight soda produced by the Soda JSC has been used as the main alkali-bearing material in the production process.

At present the Saratov Institute of Glass carries out experimental-industrial research of a new soda modification based on nepheline material supplied by the Russkii Aluminii Company, which has introduced some amendments to the technology directed to improving its properties in accordance with the requirements imposed on alkali materials used in the glass industry.

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